EFFECTS OF DIFFERENT WALKING CONSTRAINTS ON MOTOR SYNERGIES IN PEOPLE WITH CHRONIC STROKE

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Introduction

Motor synergies are functional feature of human movement control and are defined as the ability to organise a specific movement in different ways [1]. The functional role of variability in movement systems is essential for adaptation and exploration of task constraints in motor control [2]. Traditionally, greater variability in spatiotemporal gait parameters and less variability in coordinative structures (e.g. joints configurations) are indicated as the risks of falling, common in people with neurological problems [3,4]. Uncontrolled manifold (UCM) analysis can be used to identify flexibility and adaptability in joint configuration (motor synergy) which enables achievement of consistent task outcomes (e.g. step width stability). Current evidence suggests that special populations exhibit stronger motor synergies than healthy participants, in order to maintain postural stability in different phases of a gait cycle-compensating for the lack of functionality in central nervous system [5,6]. Stronger motor synergies are also associated with performance of more difficult tasks [7]. The UCM model has not been used in people with hemiplegic stroke who have difficulty in coordinating different body parts during walking under different constraints. Therefore, the aim of this study was to examine effects of different task constraints on motor synergy in people with chronic stroke.

Methods

Ten participants with hemiplegic chronic stroke voluntarily took part in this study, requiring them to walk on a treadmill at a self-selected speed. There were two walking tasks: 1) normal walking and 2) walking to step over an obstacle. Participants walked for 1 minute in each condition, and the gait cycle was recorded from and to initial contact of the same foot in successive strides. Each stride was time-normalised by spline interpolation method (0-100%). Reflective markers were placed bilaterally on the fifth metatarsal, malleolus, mid-knee and greater trochanter. The model included elemental and task variables. Elemental variables had four segments including the stance limb (affected leg), pelvis, swing-limb thigh (unaffected leg) and swing limb shank (unaffected leg). The task variable was step width (mediolateral distance between right and left ankles). Motor synergy was calculated using UCM analysis as the ratio between variability that does not change the task outcome (V_{UCM}) relative to variability that changes the task outcome (V_{ORT}) - equations 1 and 2 [7]. A series of paired t-tests were used to compare the strength of motor synergies under constraints of normal walking and walking to step over an obstacle.

$$\text{Ratio} = \left(\frac{V_{UCM} - V_{ORT}}{V_{TOT}}\right) \qquad \text{Equation (1)}$$

$$\text{Synergy Index} = \frac{1}{2}\log\left(\frac{7 + \text{Ratio}}{7/6 - \text{Ratio}}\right) \qquad \text{Equation (2)}$$

Results

Results showed that walking in the obstacle condition displayed significantly greater evidence of a motor synergy than normal walking during a whole gait cycle (t= -2.58, p=0.04, ω^2=0.59) and in the stance phase (t= -2.99, p=0.03, ω^2=0.66), but not in the swing phase (see Figure 1).

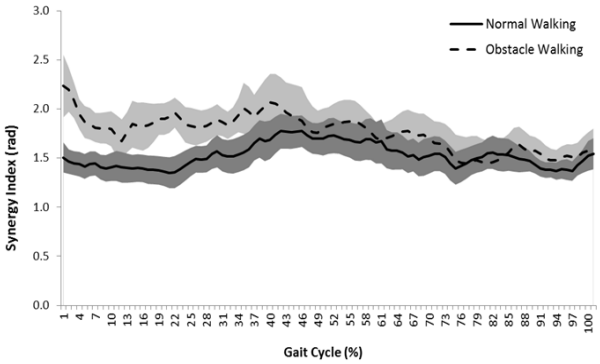

Figure 1.Motor synergy between two walking conditions in a gait cycle.

Discussion

The findings of this study showed that postural stability in people with stroke during walking is significantly affected by precision of task constraints that requires the nervous system to prevent the loss of balance through use of more compensatory movements. The requirements of motor synergy among lower limbs are increased during stance phase when the need for body weight support is increased.

References

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